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THERMAL DILATOMETRY OF FIFTEEN SAMPLES FROM THE ATK-5 DRILL CORE, ATIKOKAN, ONTARIO

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Underground Nuclear Waste Repository

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MICROMEDIA

THERMAL DILATOMETRY OF FIFTEEN SAMPLES FROM THE ATK-5 DRILL CORE, ATIKOKAN, ONTARIO

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INTRODUCTION

The work described forms a contribution to the determination of the thermal and mechanical properties of host rocks for underground nuclear waste disposal, CANMET Project 4.4.0.3.01, "Underground Nuclear Waste Repository".

Fifteen rock samples were supplied by Dr. T. J. Katsube, Resource Geophysics and Geochemistry Division, Geological Survey of Canada, for determination of their thermal expansion behaviour. All samples were sections of drill core, measuring about 45 mm in diameter and 60 to 70 mm in length. The samples were from hole ATK-5 at the site under investigation at Atikokan, Ontario, and were identified individually as follows, the numbers representing the depth of the samples in metres:

ATK 5 - 106.6 Q
ATK 5 - 224.6 Q
ATK 5 - 337.6 Q
ATK 5 - 424.1 Q
ATK 5 - 534.3 Q
ATK 5 - 625.8 Q
ATK 5 - 708.8 Q
ATK 5 - 818.3 Q
ATK 5 - 867.8 Q
ATK 5 - 918.1 Q
ATK 5 - 951.4 Q
ATK 5 - 975.4 Q
ATK 5 - 1050.3 Q
ATK 5 - 1107.4 Q
ATK 5 - 1228.6 Q

PROCEDURES AND RESULTS

To preserve, insofar as possible, the integrity of the samples for possible further work, specimens of essentially triangular cross-section (about 8-10 mm per side) were cut from the periphery of the core, parallel to the longitudinal axis. The specimens were cut to $50.8 \pm 5.08 \times 10^{-2}$ mm, with ends plane and parallel, using a precision diamond wafering saw. The actual length of each specimen was measured to the nearest 2.54×10^{-2} mm.

The thermal expansion behaviour of the specimens was measured dynamically between room temperature and about 500°C in a vertical tube-type dilatometer. The principal components of the apparatus were a nichrome-wound furnace having a uniform hot zone 75 mm long; a fused quartz tube closed at the bottom with a plane quartz disc set perpendicular to the longitudinal axis to support the specimen; and a fused quartz push-rod to translate dimensional changes in the specimen directly to an Ames dial rigidly mounted on the upper end of the tube. Specimen temperature was determined using a Pt/Pt10%Rh thermocouple with the hot junction in contact with the mid-length of the specimen, positioned centrally in the uniform hot zone of the furnace.

Heating of the furnace was manually controlled. A stable heating rate was established by about 75°C, above which the rate was maintained at 10 ± 1°C/min. Temperatures, to the nearest 1°C, and elongation, to the nearest 2.54×10^{-3} mm, were read and recorded at 3-min intervals throughout the early part of the run (when frequent adjustment was necessary) and each 2 min thereafter. Elongation was calculated as a percentage of initial length and is shown as a function of temperature in Fig. 1 to 15. The data from which the curves were plotted is given for all samples in Appendix A.

No corrections were made to compensate for expansion of the fused quartz because this is very small and regular, i.e., 0.585×10^{-6} cm/cm/^{o}C from 0^{o} to 1200^{o}C.

After the specimen was removed from the furnace and cooled to room temperature, its length was measured to the nearest 2.54×10^{-2} mm, and the permanent, or irreversible expansion was calculated.

OBSERVATIONS

The thermal expansion behaviour of this suite of samples mirrors that of the previous samples from this site, and of all granitic samples so far examined, in that the rate of expansion increases with increasing temperature. For the most part, over the depth of the hole, the total expansion at any given temperature is markedly uniform with the exception of Sample ATK 5-867.8 where, e.g., the total expansion at 250^{o}C (about 0.14_{5}%) is markedly different than that of the samples about 50 metres above and below (both about 0.20%). A repository located at this depth could be subject to above normal stresses in the surrounding rock mass. A similar anomaly may be observed at a depth of 630 metres in hole ATK 1.

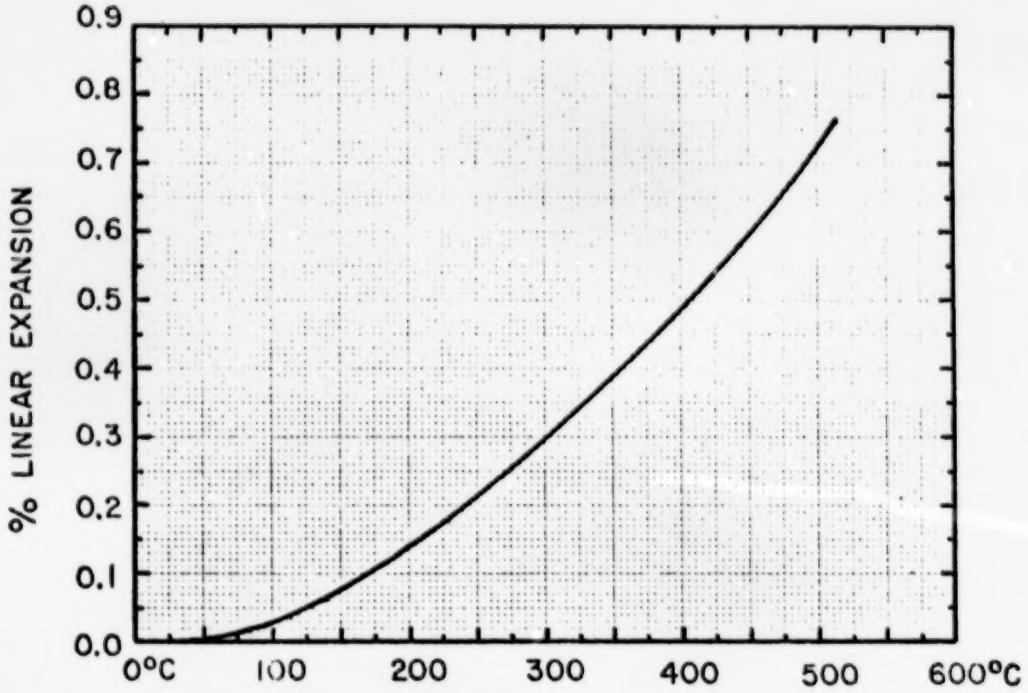

Fig. 1 - Linear thermal expansion of Sample ATK 5 - 106.6 Q.

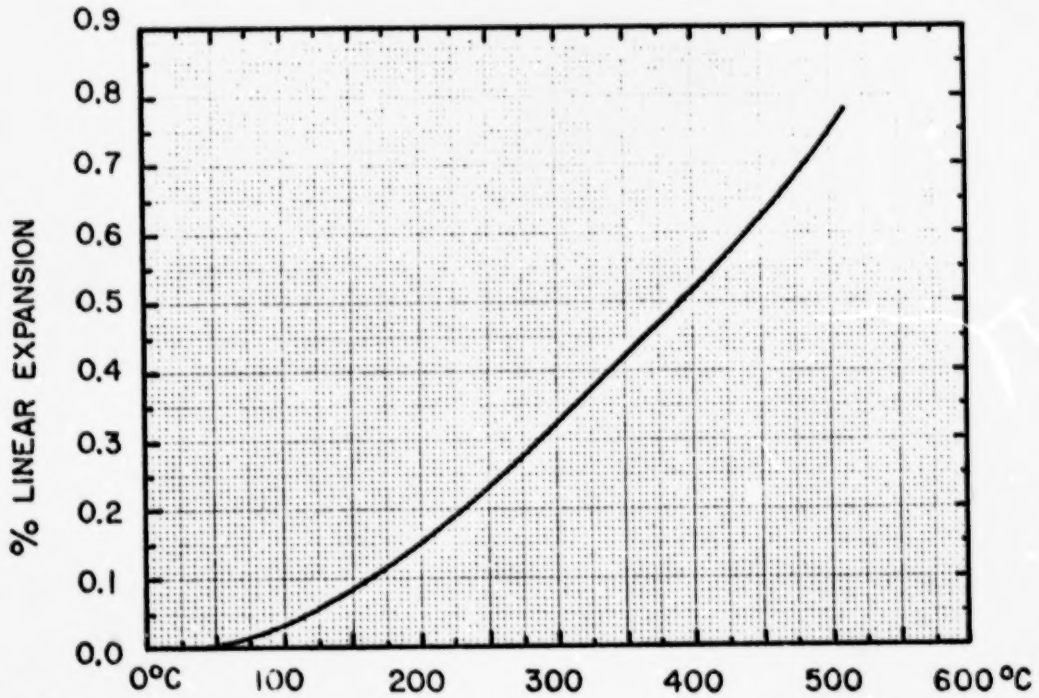

Fig. 2 - Linear thermal expansion of Sample ATK 5 - 224.6 Q.

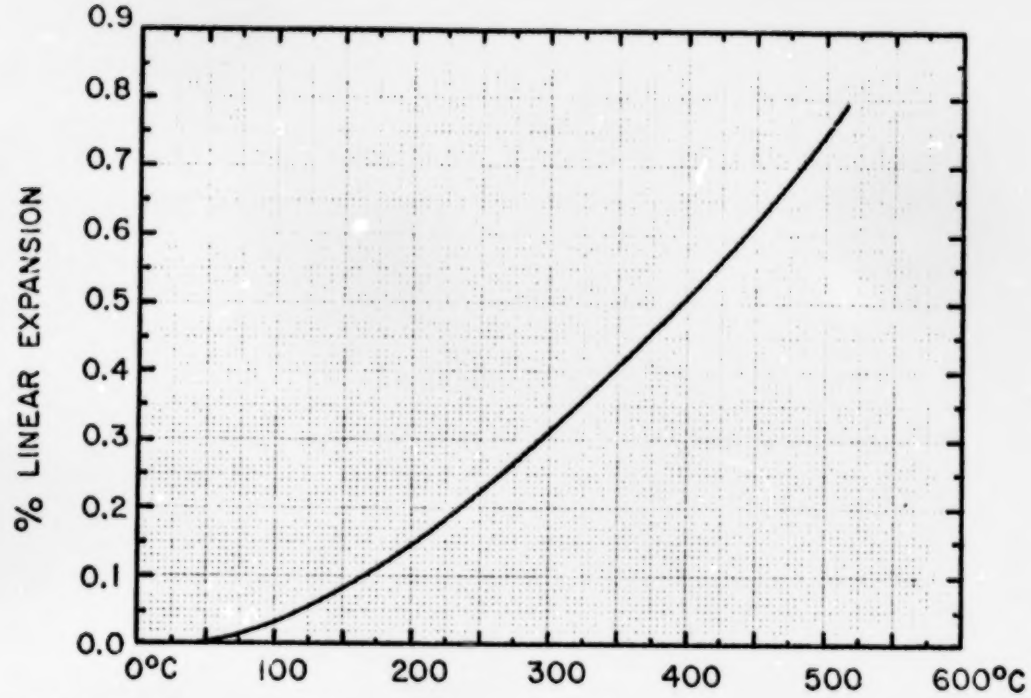

Fig. 3 - Linear thermal expansion of Sample ATK 5 - 337.6 Q.

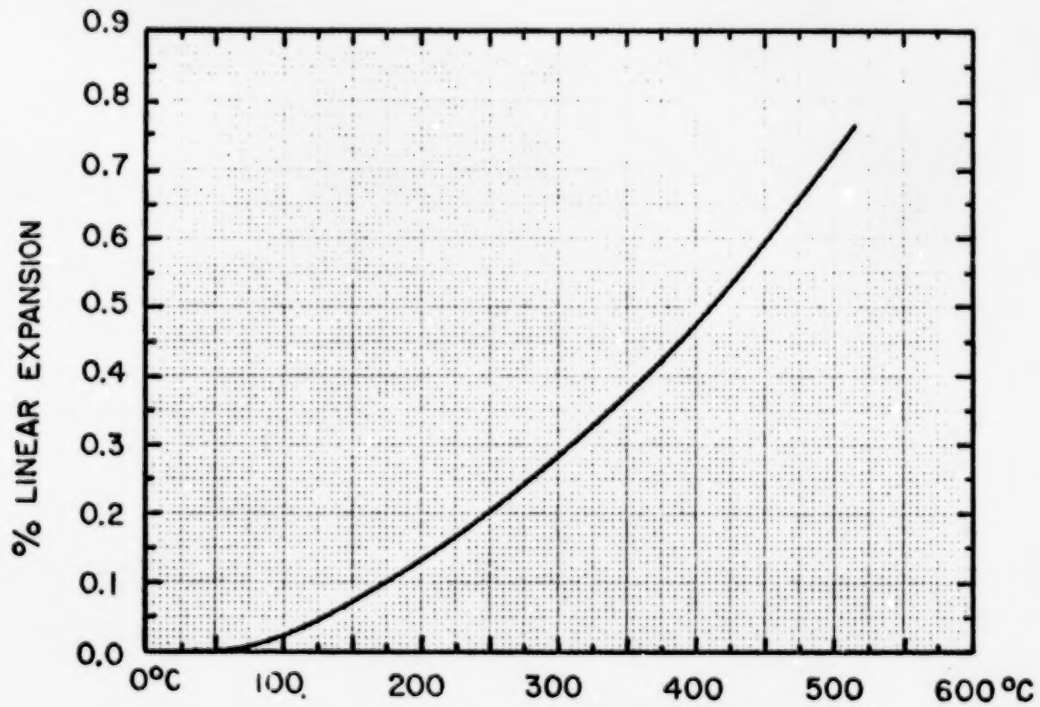

Fig. 4 - Linear thermal expansion of Sample ATK 5 - 424.1 Q.

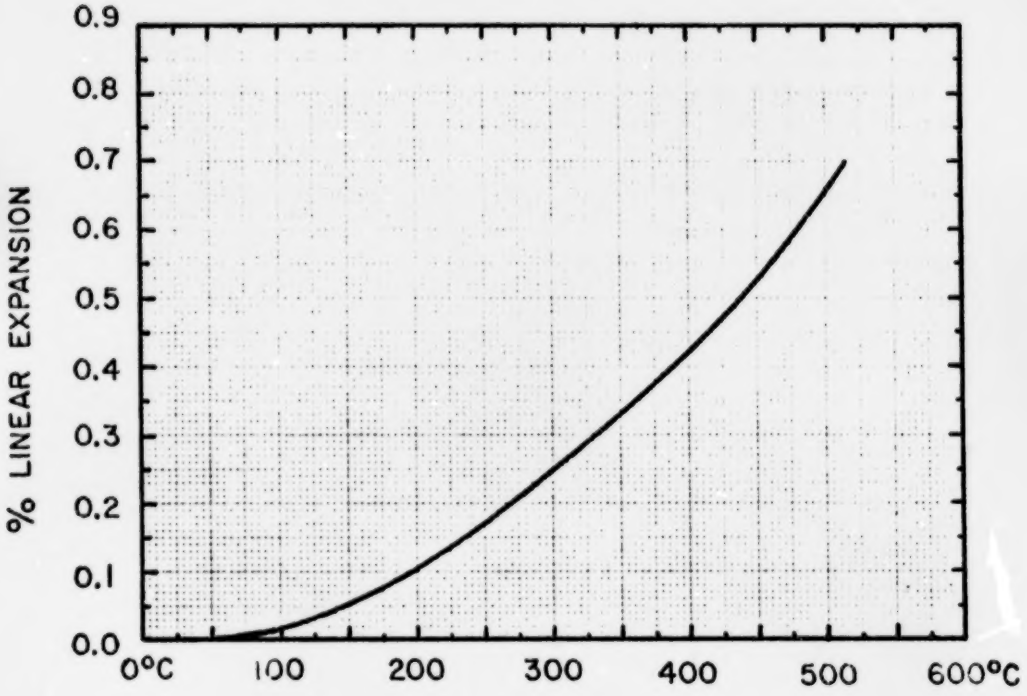

Fig. 5 - Linear thermal expansion of Sample ATK 5 - 534.3 Q.

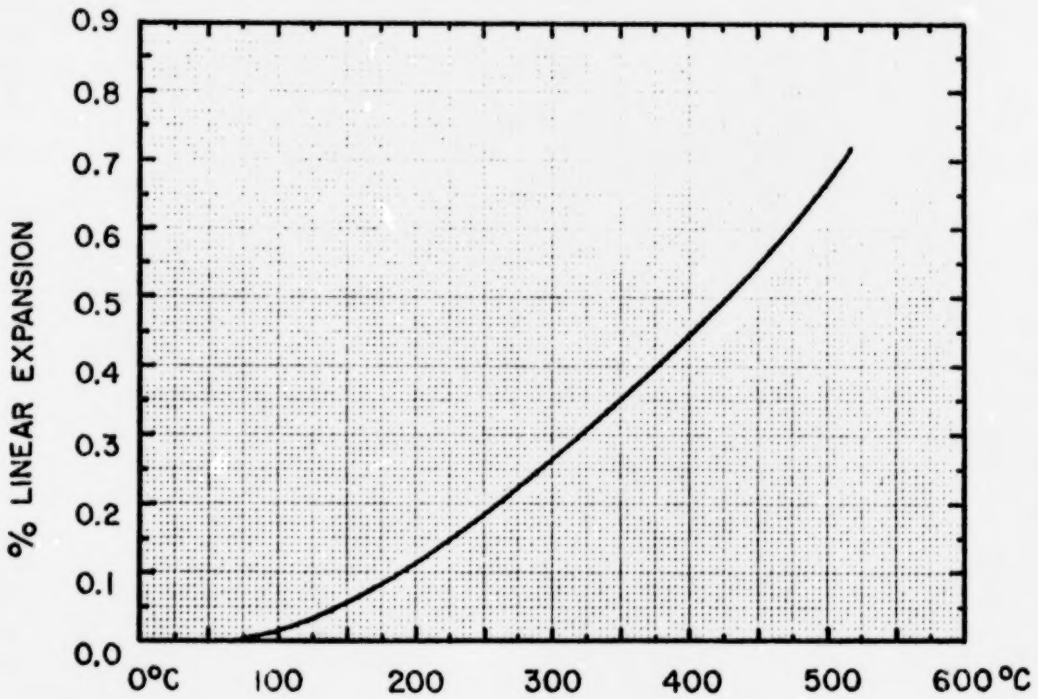

Fig. 6 - Linear thermal expansion of Sample ATK 5 - 625.8 Q.

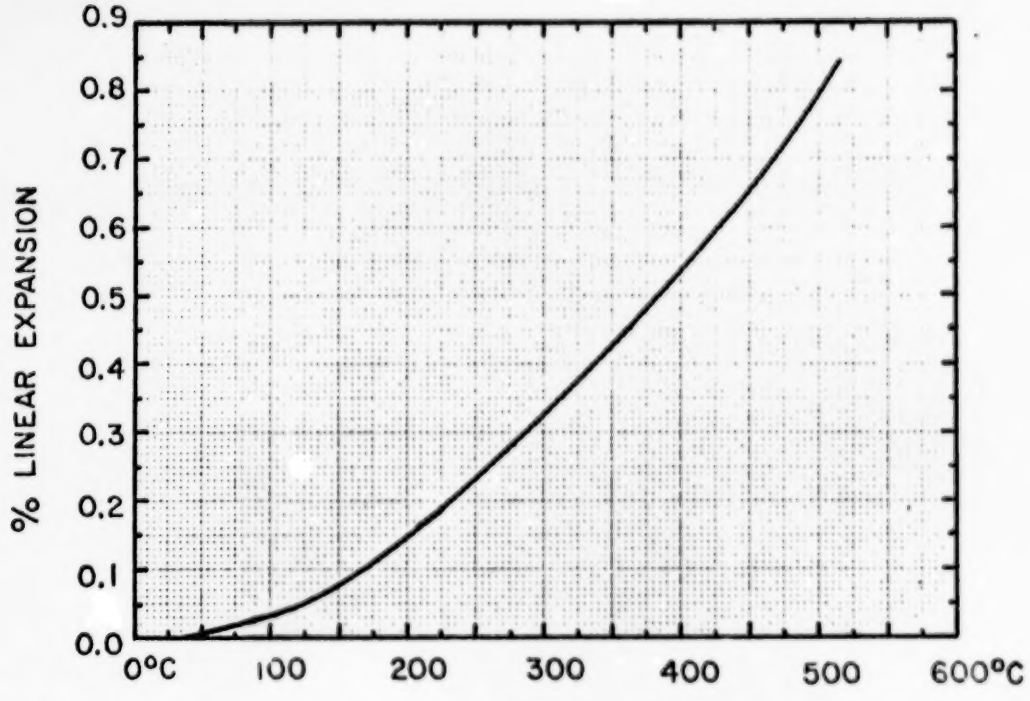

Fig. 7 - Linear thermal expansion of Sample ATK 5 - 708.8 Q.

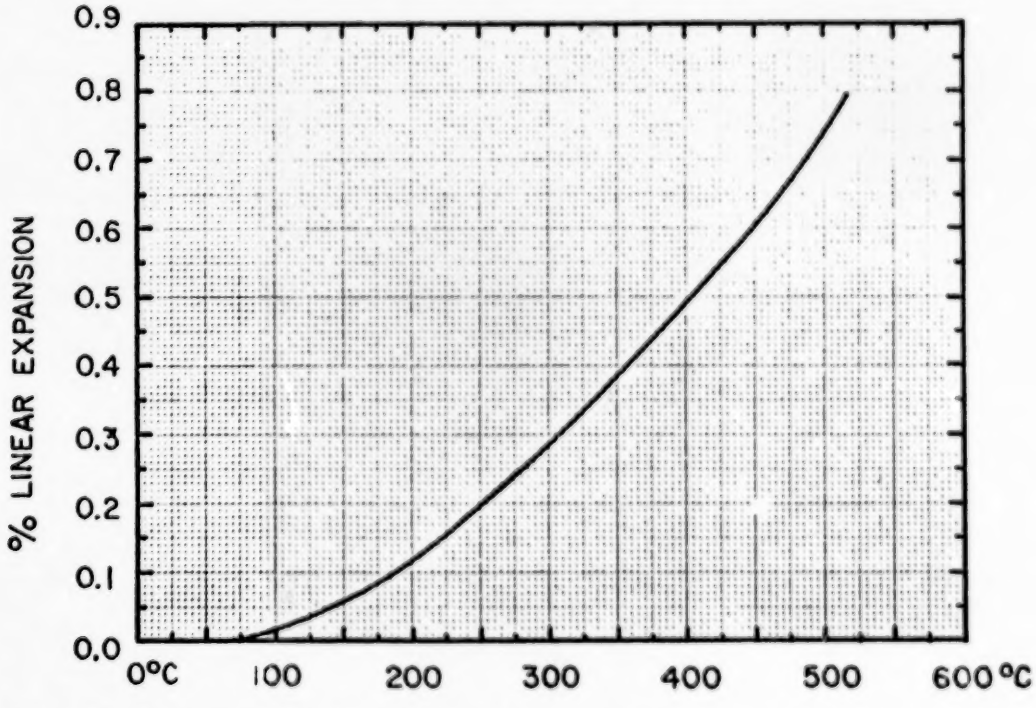

Fig. 8 - Linear thermal expansion of Sample ATK 5 - 818.3 Q.

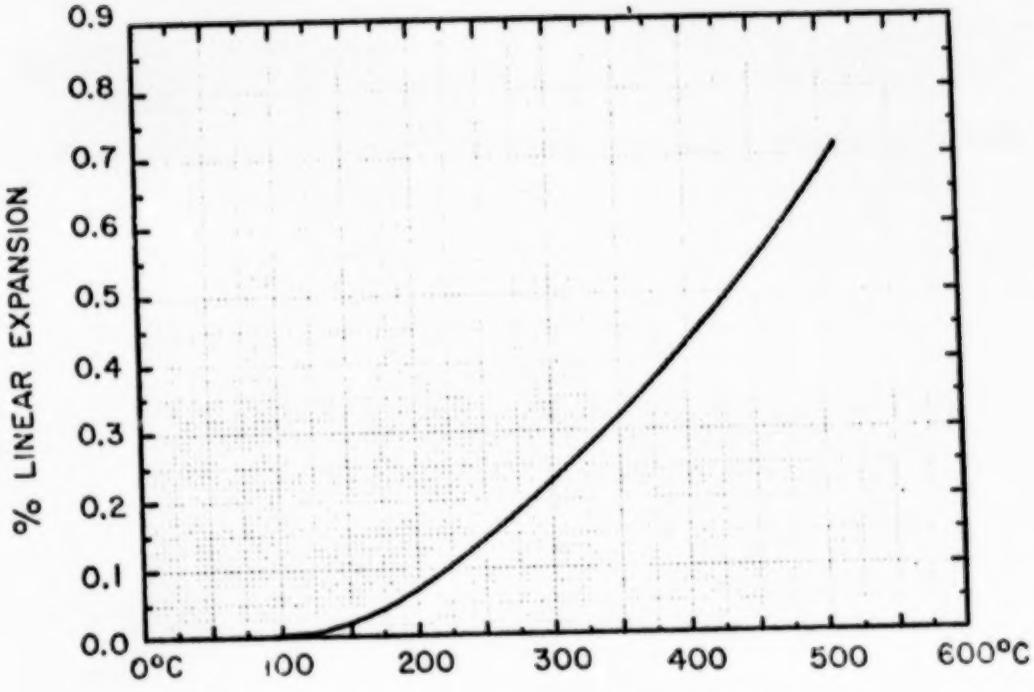

Fig. 9 - Linear thermal expansion of Sample ATK 5 - 867.8 Q.

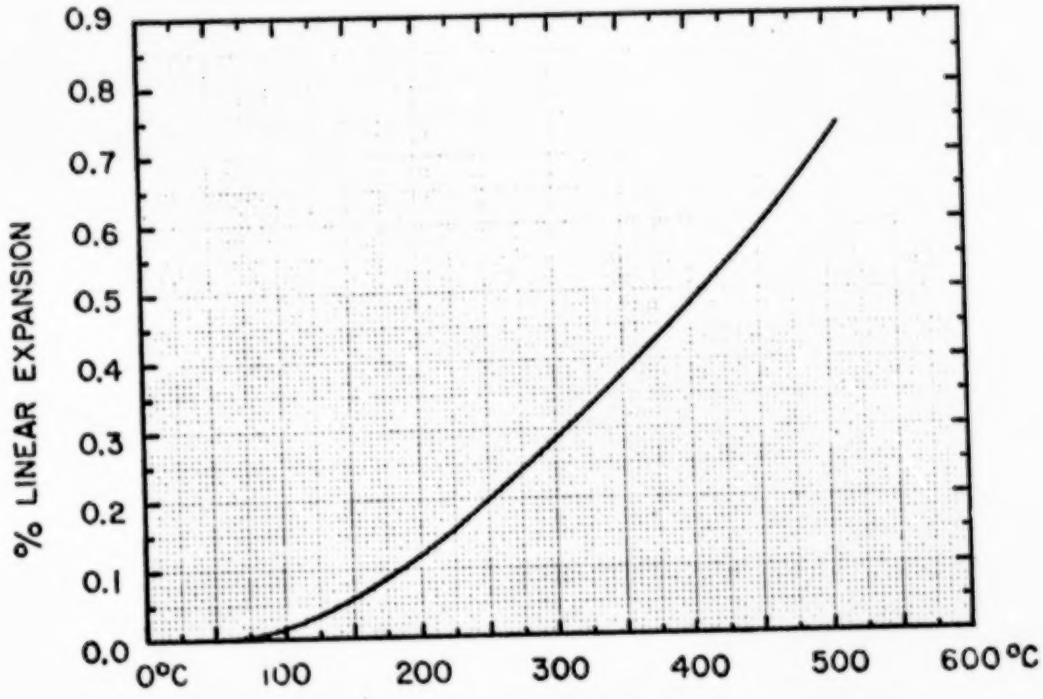

Fig. 10 - Linear thermal expansion of Sample ATK 5 - 918.1 Q.

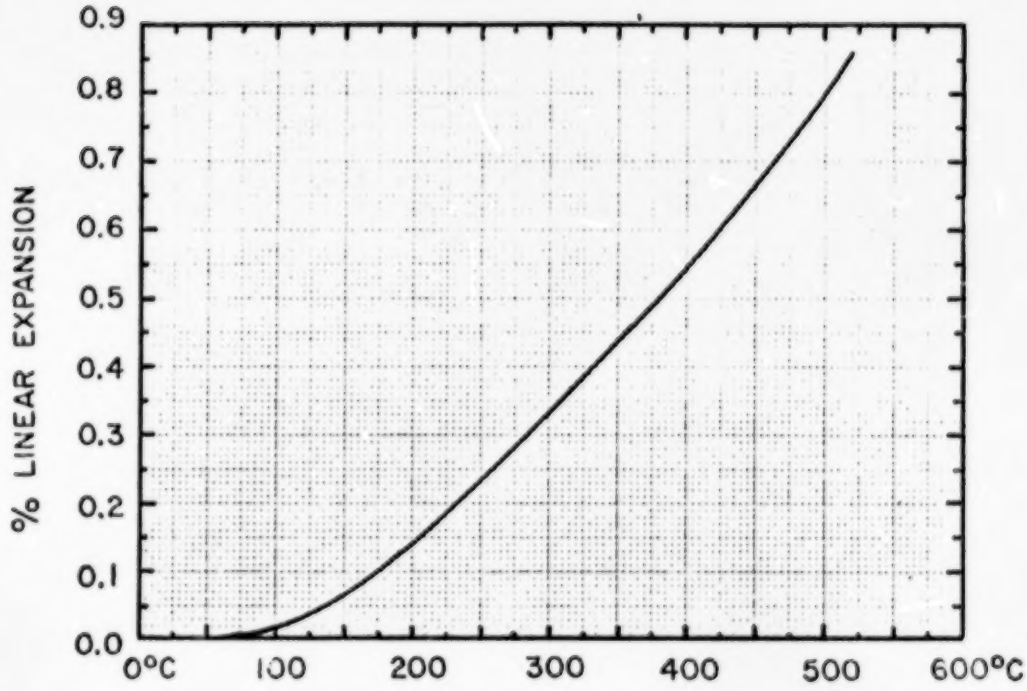

Fig. 11 - Linear thermal expansion of Sample ATK 5 - 951.4 Q.

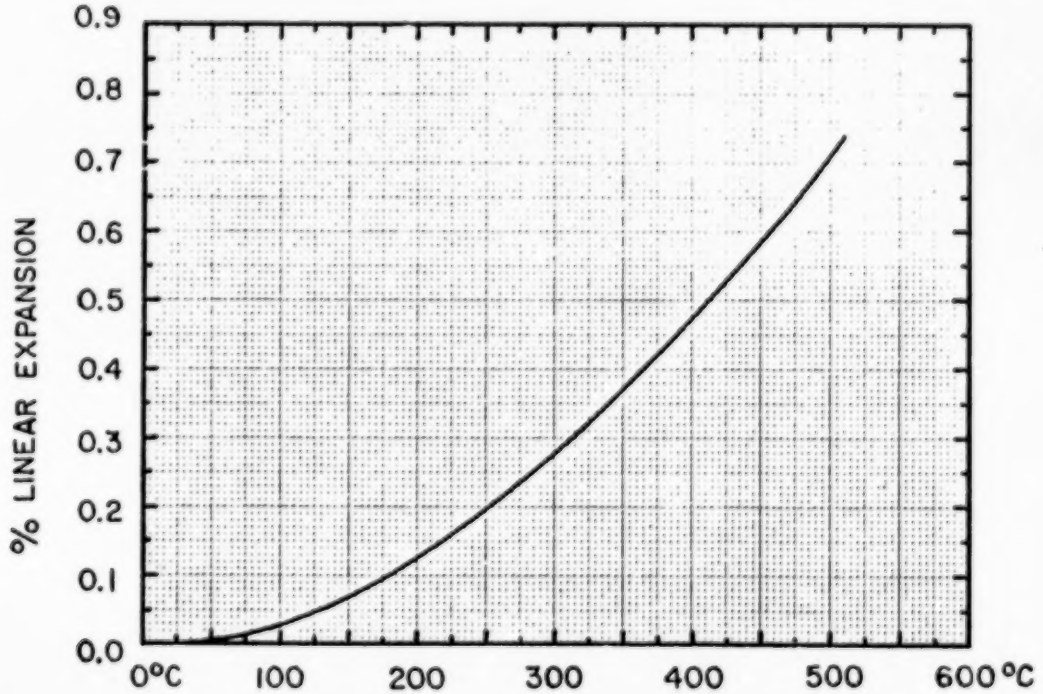

Fig. 12 - Linear thermal expansion of Sample ATK 5 - 975.4 Q.

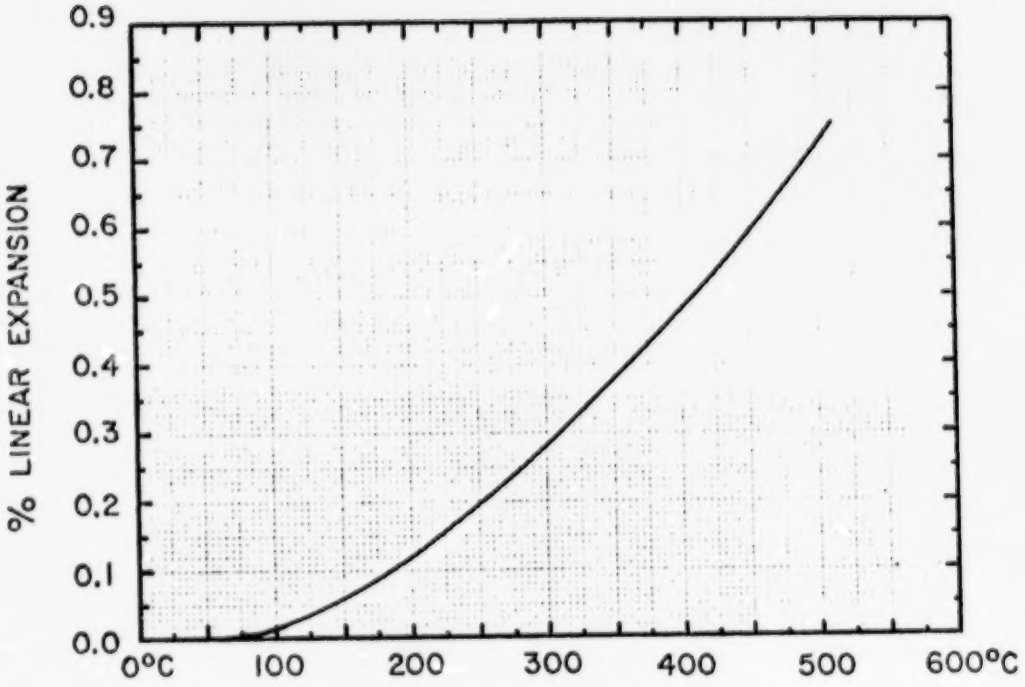

Fig. 13 - Linear thermal expansion of Sample ATK 5 - 1050.3 Q.

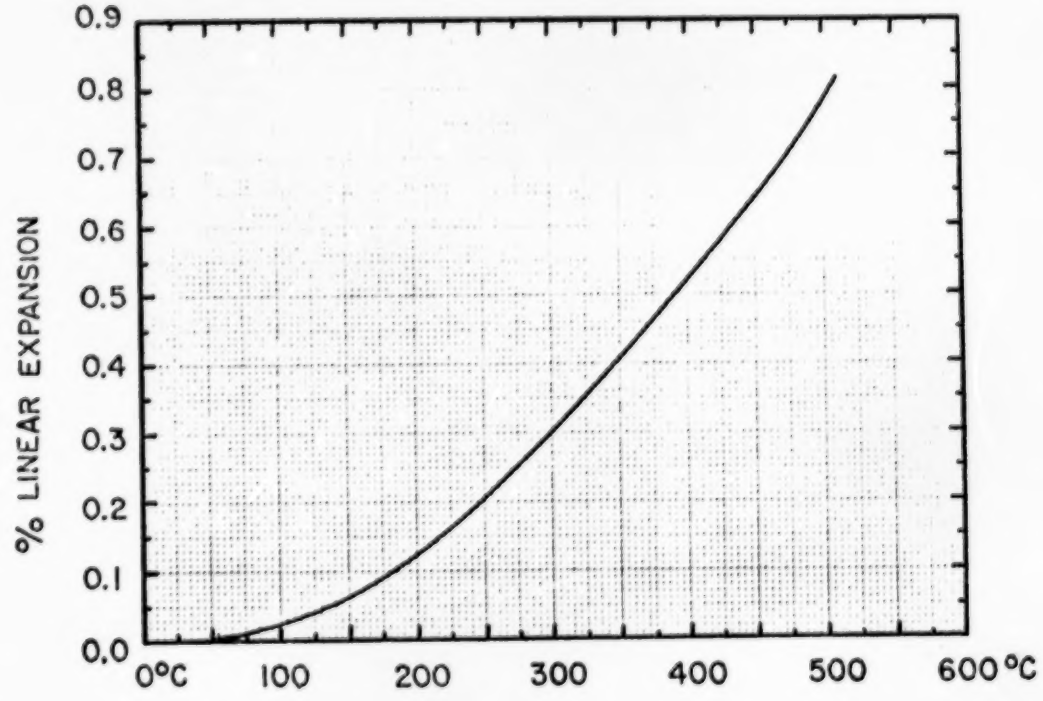

Fig. 14 - Linear thermal expansion of Sample ATK 5 - 1107.4 Q.

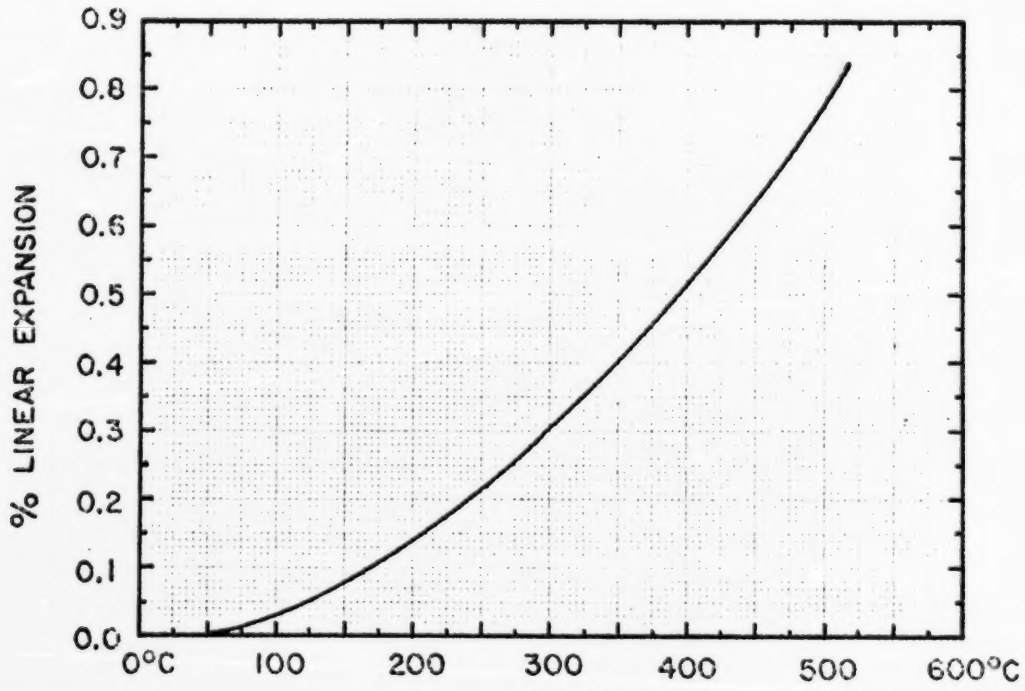

Fig. 15 - Linear thermal expansion of Sample ATK 5 - 1228.6 Q.

APPENDIX A

THERMAL EXPANSION DATA

APPENDIX A

Thermal Expansion Data

Project No. 4403.01

Date: June 17, 1982

Sample No: ATK 5- 106.6 Q

Original Length: 2.004 in.

Length after test: 2.008 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (^{o}C)	Elongation (%)
0	25	0.00
3	36	0.00
6	59	0.005
9	85	0.015
12	113	0.035
15	141	0.065
18	170	0.10
21	199	0.135
24	228	0.178
26	247	0.208
28	266	0.24
30	285	0.27
32	305	0.305
34	325	0.343
36	344	0.378
38	364	0.415
40	384	0.453
42	404	0.493
44	424	0.533
46	443	0.580
48	463	0.628
50	483	0.678
52	503	0.735
53	513	0.765

Date: June 18, 1982

Sample No: ATK 5- 224.6 Q

Original Length: 2.004 in.

Length after test: 2.008 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (^{o}C)	Elongation (%)
0	26	0.00
3	36	0.00
6	58	0.005
9	85	0.02
12	113	0.043
15	142	0.075
18	173	0.11
21	203	0.158
24	234	0.205
26	253	0.238
28	273	0.27
30	293	0.31
32	312	0.345
34	332	0.383
36	352	0.423
38	372	0.46
40	392	0.500
42	412	0.540
44	431	0.580
46	451	0.625
48	471	0.673
50	491	0.720
52	511	0.778

Project No. 4403.01

Date: June 21, 1982

Sample No: ATK 5- 337.6 Q

Original Length: 2.005 in.

Length after test: 2.009 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	23	0.00
3	32	0.00
6	51	0.003
9	75	0.015
12	101	0.035
15	130	0.06
18	160	0.095
21	190	0.133
24	221	0.175
26	241	0.21
28	262	0.245
30	282	0.28
32	302	0.315
34	323	0.355
36	343	0.395
38	363	0.435
40	383	0.475
42	404	0.520
44	424	0.560
46	444	0.605
48	464	0.655
50	484	0.705
52	505	0.763
53	515	0.793

Date: June 22, 1982

Sample No: ATK 5- 424.1 Q

Original Length: 1.997 in.

Length after test: 2.001 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	24	0.00
3	36	0.00
6	61	0.003
9	90	0.018
12	118	0.038
15	147	0.065
18	177	0.103
21	207	0.14
24	236	0.18
26	256	0.213
28	276	0.245
30	295	0.278
32	315	0.31
34	335	0.348
36	355	0.385
38	375	0.418
40	394	0.46
42	414	0.508
44	434	0.558
46	454	0.605
48	474	0.655
50	494	0.705
52	514	0.765

Project No. 4403.01

Date: June 23, 1982

Sample No: ATK 5- 534.3 Q

Original Length: 1.998 in.

Length after test: 2.002 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	24	0.00
3	34	0.00
6	55	0.003
9	81	0.01
12	108	0.025
15	136	0.04
18	166	0.068
21	195	0.10
24	225	0.135
26	245	0.163
28	264	0.193
30	284	0.223
32	303	0.255
34	323	0.285
36	343	0.315
38	363	0.353
40	383	0.39
42	403	0.43
44	423	0.47
46	443	0.510
48	463	0.555
50	484	0.610
52	504	0.665
53	514	0.700

Date: June 24, 1982

Sample No: ATK 5- 625.8 Q

Original Length: 1.997 in.

Length after test: 2.001 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	25	0.00
3	40	0.00
6	67	0.00
9	94	0.01
12	122	0.028
15	151	0.055
18	180	0.088
21	210	0.125
24	240	0.168
26	260	0.198
28	280	0.23
30	300	0.26
32	319	0.295
34	339	0.333
36	359	0.37
38	379	0.408
40	399	0.448
42	418	0.485
44	438	0.525
46	458	0.570
48	477	0.515
50	497	0.665
52	517	0.720

Project No. 4403.01

Date: June 25, 1982

Sample No: ATK 5- 708.8 Q

Original Length: 1.996 in.

Length after test: 1.999 in.

Irreversible expansion: 0.15%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	25	0.00
3	38	0.00
6	62	0.01
9	89	0.025
12	118	0.045
15	147	0.075
18	177	0.118
21	207	0.16
24	237	0.21
26	257	0.245
28	276	0.28
30	296	0.315
32	316	0.355
34	335	0.395
36	355	0.435
38	375	0.48
40	395	0.525
42	415	0.570
44	435	0.618
46	455	0.668
48	475	0.720
50	495	0.778
52	515	0.845

Date: June 28, 1982

Sample No: ATK 5- 818.3 Q

Original Length: 1.996 in.

Length after test: 2.000 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	25	0.00
3	42	0.00
6	70	0.00
9	97	0.013
12	125	0.035
15	154	0.063
18	183	0.095
21	212	0.135
24	241	0.185
26	260	0.215
28	279	0.25
30	298	0.285
32	317	0.315
34	337	0.355
36	357	0.40
38	377	0.44
40	397	0.483
42	417	0.528
44	437	0.573
46	457	0.618
48	477	0.670
50	497	0.725
52	517	0.793

Project No. 4403.01

Date: June 29, 1982

Sample No: ATK 5- 867.8 Q

Original Length: 2.000 in.

Length after test: 2.004 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	26	0.00
3	36	0.00
6	59	0.00
9	85	0.00
12	113	0.003
15	142	0.015
18	171	0.04
21	201	0.07
24	231	0.115
26	251	0.145
28	271	0.175
30	291	0.21
32	311	0.248
34	331	0.283
36	351	0.32
38	371	0.365
40	391	0.408
42	412	0.455
44	432	0.500
46	452	0.548
48	471	0.600
50	491	0.655
52	511	0.718

Date: June 30, 1982

Sample No: ATK 5- 918.1 Q

Original Length: 2.004 in.

Length after test: 2.008 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	26	0.00
3	35	0.00
6	56	0.00
9	81	0.005
12	108	0.023
15	137	0.048
18	167	0.078
21	197	0.115
24	227	0.16
26	247	0.193
28	267	0.225
30	287	0.263
32	307	0.30
34	327	0.335
36	346	0.37
38	366	0.413
40	387	0.455
42	408	0.500
44	428	0.545
46	448	0.588
48	468	0.633
50	488	0.683
52	508	0.740

Project No. 4403.01

Date: July 2, 1982

Sample No: ATK 5- 951.4 Q

Original Length: 2.003 in.

Length after test: 2.008 in.

Irreversible expansion: 0.25%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	25	0.00
3	38	0.00
6	63	0.00
9	90	0.01
12	118	0.03
15	148	0.065
18	178	0.105
21	208	0.155
24	237	0.21
26	257	0.248
28	277	0.285
30	298	0.325
32	318	0.37
34	338	0.413
36	358	0.455
38	378	0.495
40	398	0.540
42	419	0.588
44	439	0.638
46	459	0.690
48	479	0.740
50	499	0.795
52	520	0.860

Date: July 7, 1982

Sample No: ATK 5-975.4 Q

Original Length: 2.000 in.

Length after test: 2.004 in.

Irreversible expansion 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	27	0.00
3	37	0.00
6	60	0.008
9	86	0.02
12	114	0.04
15	144	0.065
18	174	0.095
21	204	0.13
24	234	0.173
26	254	0.203
28	273	0.235
30	293	0.268
32	313	0.30
34	332	0.338
36	352	0.375
38	372	0.415
40	392	0.458
42	412	0.500
44	431	0.543
46	451	0.585
48	470	0.630
50	490	0.683
52	510	0.740

Project No. 4403.01

Date: July 8, 1982

Sample No: ATK 5- 1050.3 Q

Original Length: 2.000 in.

Length after test: 2.004 in.

Irreversible expansion: 0.2%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	29	0.00
3	40	0.00
6	63	0.00
9	89	0.005
12	115	0.025
15	143	0.050
18	172	0.085
21	201	0.12
24	230	0.168
26	250	0.20
28	270	0.23
30	290	0.265
32	310	0.30
34	330	0.34
36	350	0.38
38	370	0.42
40	390	0.46
42	410	0.500
44	430	0.545
46	449	0.590
48	470	0.640
50	490	0.695
52	512	0.750

Date: July 9, 1982

Sample No: ATK 5- 1107.4 Q

Original Length: 2.000 in.

Length after test: 2.003 in.

Irreversible expansion: 0.15%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	29	0.00
3	38	0.00
6	58	0.003
9	84	0.015
12	111	0.03
15	140	0.055
18	170	0.085
21	200	0.125
24	230	0.17
26	250	0.208
28	270	0.245
30	289	0.283
32	310	0.32
34	330	0.365
36	350	0.41
38	370	0.455
40	390	0.500
42	410	0.545
44	429	0.590
46	449	0.640
48	470	0.690
50	490	0.750
52	510	0.813

Project No. 4403.01

Date: August 3, 1982

Sample No: ATK 5- 1228.6 Q

Original Length: 2.000 in.

Length after test: 2.003 in.

Irreversible expansion: 0.15%

Elapsed Time (min)	Temperature (°C)	Elongation (%)
0	26	0.00
3	34	0.00
6	51	0.00
9	75	0.01
12	102	0.03
15	131	0.055
18	162	0.09
21	192	0.128
24	223	0.175
26	243	0.208
28	264	0.24
30	284	0.275
32	304	0.31
34	324	0.35
36	344	0.39
38	364	0.435
40	385	0.48
42	405	0.528
44	425	0.575
46	445	0.625
48	465	0.68
50	485	0.735
52	506	0.800
53	516	0.835

Date:

Sample No:

Original Length:

Length after test:

Irreversible expansion:

Elapsed Time (min)	Temperature (°C)	Elongation (%)